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ALUMINUM VEHICLE BODY

TECHNICAL FIELD

[0001] This invention relates to the manufacture of automotive vehicle bodies and, more particularly, to the color finishing of vehicle bodies with external panels and components made of aluminum alloys.

BACKGROUND OF THE INVENTION

[0002] Current automotive vehicle bodies often contain one or more aluminum alloy body panels or other body parts that are included in an overall body structure that is formed mostly of steel panels and frame members. Sometimes polymer composite parts are also included in the body structure. When such body structures have been formed they are provided with a corrosion resistant and decorative finish by, e.g., the successive application of a zinc galvanize coating, an electrolytically applied primer paint coating, the spray application of one or more color paint layers, and the spray application of one or more protective clear paint coating layers.

[0003] A relatively small portion of vehicle bodies are made with substantially all aluminum alloy external panels or structure members. While all-aluminum vehicle bodies are not given a galvanize coating they have been painted in conventional automotive paint shops and given the described sequence of primer paint coats and colored and clear paint layers.

[0004] It is an object of this invention to provide a different method of color finishing aluminum automotive vehicle bodies.

SUMMARY OF THE INVENTION

[0005] Disclosed herein is a method for the color finishing of aluminum bodies for motor vehicles. The method comprises anodizing all of

the aluminum surfaces of, or for, the body and coloring all aluminum surfaces. Preferably, all of the surfaces for a given body are anodized at the same time and then colored at the same time for efficiency and for uniform decorative effect. The coloring of the aluminum body may be accomplished by an adsorptive coloring process, an electrolytic coloring process, an interference coloring process, or a suitable combination of the foregoing processes. In general, it is preferred to employ an electrolytic coloring process for automobile bodies.

[0006] It is recognized that aluminum bodies have been made in different architectures. Sometimes the many body panels are welded together in an integral structure sometimes called Body Frame Integral (BFI). In other body designs a frame (for example, of shaped tube members) is fabricated and then body panels (e.g., doors, fenders, hood and trunk lid) are attached to the frame – a body on frame (BOF) architecture. The practice of this invention is applicable to all such vehicle body architectures and to all-aluminum body subsets. One or more bodies or collection of external body part members would be processed together in the practice of this invention.

[0007] Aluminum frame members and body panels are each made of available aluminum alloys having properties suitable for the forming of the members or panels and for the service of each member. Aluminum and aluminum alloys are generally classified with a four-digit system that is based upon the principal alloying element. For example, Group 5000 generally refers to aluminum alloys that contain magnesium as the principal alloying additive whereas Group 6000 series refers to aluminum alloys that contain both magnesium and silicon as the principal alloying additives. These and other commercial alloys are used in vehicle bodies.

[0008] In one embodiment, a method for color anodizing surfaces of an aluminum vehicle body, or set of external body parts, comprises cleaning the body surfaces in an alkaline cleaning process; etching the aluminum

surfaces in an etching process; deoxidizing the aluminum surfaces in a deoxidizing bath; anodizing the aluminum surfaces in an anodizing bath; dipping the aluminum surfaces in a nitric acid bath; coloring the aluminum surfaces; and cold sealing or heat sealing the colored aluminum surfaces.

[0009] In another embodiment, a method of color-anodizing aluminum motor vehicle bodies, or set of body components, comprises immersing said aluminum motor vehicle body, or set of body components, in an alkaline cleaning solution having an elevated temperature to remove surface dirt or contaminants; immersing the bodies or components in an etching or electropolishing bath to remove the thin natural oxide coating from the aluminum body or body components; immersing the aluminum body or component set in an acidic solution to de-smut or deoxidize the aluminum body or body components; immersing the aluminum body or components in a hot solution of one or more of nitric, phosphoric, and sulfuric acids to bright dip/electro-polish said aluminum body or components; anodizing the aluminum body or body components in an acid solution; coloring the aluminum body or components in a process selected from the group of processes consisting of adsorptive coloring, electrolytic coloring, and interference coloring; dipping the aluminum body or components in a solution of fluoride or silica compounds in the presence of nickel salts to cold seal the aluminum body or components; immersing the aluminum body or components in deionized water at a temperature of about 90°C to about 100°C; and drying them.

[0010] Another embodiment of the invention is the colored aluminum automotive body or set of component parts for a body produced by an anodizing and coloring process comprising: cleaning the aluminum automotive body or body components in an alkaline cleaning bath for about 0.1 to about 30 minutes; electro-polishing or etching the aluminum automotive body or body parts in a sodium hydroxide solution for about 0.1 to about 30 minutes; de-smutting them in a nitric acid de-smutting bath for

about 0.1 to about 2 minutes; bright dipping them in a strong phosphoric acid solution; anodizing them in a sulfuric acid bath at a current density of about 10 to about 20 A/ft² to form a porous aluminum oxide surface at a thickness of about 5 micrometers to about 50 um; coloring them, wherein coloring comprises impregnating a dye into the porous aluminum oxide surface, electrolytically depositing a metal into the porous aluminum oxide surface, or electrolytically depositing a metal in enlarged pores in the aluminum oxide surface to form an interference coating, or a combination comprising at least one of the foregoing coloring processes; and sealing the aluminum body panel or set of body components to produce the colored aluminum automotive body.

[0011] A preferred result of the subject process is to produce a substantially all-aluminum vehicle body in which the aluminum panels and surfaces are anodized at the same time and the porous oxide surfaces colored by suitable deposition of dyes or metal particles or the like in the pores of the anodized surfaces. When the coloring substance has been incorporated into the pores of the aluminum surfaces the pores are sealed to produce a durable decorative finish. In general, it is preferred to produce the decorative finish by electrolytic deposition of metal particles in the pores to produce a surface that is decorative by optical reflection or interference phenomena. The anodized aluminum parts are immersed in an acid bath containing an inorganic metal salt such as tin, nickel, cobalt or copper and current is applied to deposit the metal into the bases of the pores. Usually the resulting colors, ranging from light to very dark depend on the depositions times and metal deposited.

[0012] The above described and other features are described and illustrated by the following figure and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The Drawing shows a schematic representation of a method for color anodizing an aluminum motor vehicle body, a set of panel and components for a body, or the like.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0014] Disclosed herein is a method for color anodizing aluminum motor vehicle bodies and sets of aluminum components for assembly into a said body. It is contemplated that once made an entire body or group of bodies be carried through the processes described below. As an alternative to color anodizing a constructed body the process is applied to a full collection of the visible panels and any other body components intended to be colored in the completed body for consumer acceptance in a vehicle for sale. Such a collection of panels and components for bodies is hereinafter included in the term “bodies” or “vehicle bodies” as used in this specification.

[0015] The anodizing process generally includes applying a current in an acid anodizing bath to control the quality of the anodized coating to receive a durable colored coating by any one of or a combination of coloring processes. Such coloring processes are described below. Alternatively, the anodizing process can be used to produce a clear coating.

[0016] The anodizing process may be performed on automotive vehicle bodies fabricated from pure aluminum or from aluminum alloys. Body styles that may be color-anodized include body frame integral (BFI) styles, body on frame (BOF) styles, and space frames. Although the anodizing and coloring processes hereinafter refer to vehicle bodies fabricated from aluminum, it should be understood that the process of color anodizing described below is also applicable to frames or components fabricated from aluminum alloys. Exemplary aluminum alloys that may be

color anodized include, but are not limited to, aluminum-copper alloys (Al-Cu, e.g., Group 2000 aluminum alloys), aluminum manganese alloys (Al-Mn, e.g., Group 3000 aluminum alloys), aluminum silicon alloys (Al-Si, e.g., Group 4000 aluminum alloys), aluminum magnesium alloys (Al-Mg, e.g., Group 5000 aluminum alloys), aluminum magnesium silicon alloys (Al-Mg-Si, e.g., Group 6000 aluminum alloys), and aluminum zinc alloys (Al-Zn, e.g., Group 7000 aluminum alloys). Any of the foregoing exemplary aluminum alloys may further include an alloying additive such as silicon.

[0017] Referring now to The Drawing, a process for color-anodizing aluminum motor vehicle bodies is schematically shown at 10. The process 10 generally comprises various procedures including, but not limited to, removing surface contaminants such as grease or dirt via an alkaline and/or acid cleaning of the surfaces, etching and/or electropolishing, anodizing to form a porous aluminum oxide coating, coloring, and sealing. Coloring processes by which the anodized coating is colored include adsorptive coloring, electrolytic coloring, interference coloring, or combinations comprising at least one of the foregoing coloring processes.

[0018] Process 10 is generally carried out in an assembly line procedure in which an automated handling system guides a number of bodies through a series of treatment vessels. One or several bodies are simultaneously treated in each step of process 10 by being automatically deposited in and retrieved from the treatment vessels. The treatment vessels are arranged to sequentially receive batches of bodies. In one exemplary embodiment, each treatment vessel is preferably about 6,800 cubic feet (ft³) and preferably dimensioned so as to accommodate about eight motor vehicle bodies. The total residence time of a motor vehicle body in process 10 is preferably about 1 to about 5 hours, with about 1.5 to about 4 even more preferred, and with about 2 to about 3 hours most preferred.

[0019] If the aluminum vehicle body carries contaminants such as cutting oils or protective coatings disposed on the surfaces of the body, the

contaminants are preferably removed from the surfaces prior to initiation of process 10. Removal of the contaminants may be accomplished by, for example, vapor degreasing the body or contacting the body with an acid cleaning solution. In a vapor degreasing process, the contaminants may be removed by contacting the body with the vapors of materials such as 1, 1, 1 trichloroethane, trichloroethylene, or perchloroethylene. In the event that the aluminum alloy body as received does not have this type of contamination, then this step may be omitted.

[0020] In one exemplary step of process 10, contaminants (e.g., “shop dirt”) are removed from the aluminum bodies in an alkaline cleaning process 12. The alkaline cleaning process 12 utilizes an alkaline cleaning solution that preferably comprises various sodium salts with synthetic detergents, emulsifiers, flocculants, one or more surfactants, wetting agents, and the like. For example, a suitable alkaline cleaning solution comprises trisodium phosphate at a concentration of about 5 grams per liter (g/L). Cleaning of an aluminum vehicle body is most effectively conducted with the alkaline cleaning solution when the solution is well mixed and maintained at an elevated temperature. Preferably, the solution is maintained at a temperature of about 20 degrees centigrade (°C) to about 79°C. The immersion time for the aluminum bodies in the alkaline cleaning solution is preferably about 0.1 to about 30 minutes, with an immersion time of about 1 to about 20 minutes more preferred, with an immersion time of about 5 to about 15 minutes even more preferred, and with an immersion time of about 10 minutes most preferred.

[0021] Subsequent to alkaline cleaning process 12, the aluminum body is preferably rinsed in a rinsing cycle. The rinsing cycle comprises flushing the surfaces of the body with hot water to remove any traces of the alkaline cleaning solution as well as any residual contaminants loosened by the alkaline cleaning solution and remaining at the surface of the body.

[0022] Once sufficiently rinsed, the body undergoes an etching or electropolishing process 16 to improve the surface finish, i.e., decrease roughness. Aluminum has a thin natural oxide coating on the surface that has to be removed prior to anodizing. This oxide coating is removed during the etching or electropolishing step. The purpose of etching or electropolishing is also to provide a matte appearance, and to remove scratches in the surface.

[0023] In etching, the body is preferably immersed in a bath containing an aqueous sodium hydroxide solution often together with various commercial additives to give an even matte finish. Increasing the temperature of the etchant bath will increase the rate of etching. In a preferred embodiment, the etching process is about 0.1 to about 30 minutes, with about 1 to about 20 minutes more preferred, with about 5 to about 15 minutes even more preferred, and with about 10 minutes most preferred.

[0024] The body is then subjected to a de-smutting or deoxidizing process 18 in which the body is dipped in a de-smutting or deoxidizing bath. The de-smutting or deoxidizing bath removes any smut (e.g., soot), oxide particles, intermetallics, silicon, and the like, which are insoluble in the alkaline cleaning solution of alkaline cleaning process 12 and/or etching or electropolishing process 16 and are not removed in the subsequent rinse cycles. A suitable de-smutting bath is a 20% by volume aqueous solution of nitric acid at ambient temperature. The immersion time of the aluminum body in the de-smutting or deoxidizing bath is based on the rate at which the surface of the body is etched to remove the smut layer by the particular acid solution employed. The immersion time for the body is preferably about 15 seconds to about 5 minutes, with about 30 seconds to about 2 minutes more preferred, and with about one minute most preferred. Suitable acid solutions not only remove smut and deoxidize the aluminum, but they further preferably do not have a detrimental effect on the aluminum surface when the body is subjected to extended immersion times. The aluminum bodies

may then be rinsed in the rinse cycle to remove any residue of the acid solution.

[0025] Following de-smutting or deoxidizing, the body may be subjected to a bright dip/electropolishing process 20. Bright dip/electropolishing process 20 comprises immersing the body into a hot aqueous solution containing a mixture of nitric and phosphoric acids. The combination of the dissolution of aluminum by phosphoric acid and the passivation of the surface by the nitric acid result in an overall reduction of the surface profile with simultaneous smoothing and brightening of the metal surface. A suitable mixture is one containing (by volume) about 3 % nitric acid, about 83 % phosphoric acid, about 14 % distilled water and 36g/l aluminum. This mixture is preferably held at an elevated temperature. Preferably, the temperature of the bright dip solution is about 10°C to about 95°C, with about 38°C to about 95°C more preferred, and with about 65°C to about 95°C even more preferred. The aluminum alloy body is preferably immersed in the bright dip solution for at least about 2 minutes, and preferably up to about 10 minutes. The body may then be rinsed in a rinse cycle.

[0026] In electropolishing, the body is immersed as a cathode in an electrolytic bath preferably containing acidic reagents and connected to an anode of the electrolytic bath. Direct current is made to flow from the anode to the cathodic vehicle body to do essentially the opposite of a plating process. Electric fields naturally focus on microscopic peaks, increasing the local material removal rate over that of valleys, resulting in a significantly smoother and more reflective surface with minimal material removal. Upon completion of the etching or electropolishing process 16, the body is preferably subjected to a rinse cycle.

[0027] In a preferred embodiment, the electropolishing process is about 0.1 to about 30 minutes, with about 1 to about 20 minutes more

preferred, with about 5 to about 15 minutes even more preferred, and with about 10 minutes most preferred.

[0028] After bright dip/electropolishing process 20, the vehicle body is anodized in an anodizing process 22. Anodizing is an electrochemical conversion process performed in an acidic solution in which the surface of the aluminum metal layer is converted to a porous aluminum oxide film at an anode during the application of electrical current. In anodizing process 22, the body is configured as an anode. A direct current (DC) is applied to a suitable cathode such as a flat bar of stainless steel, and electrolytic commutation is maintained between the cathode and the anode through a sulfuric acid electrolyte. Upon application of the direct current, oxygen gas is evolved at the anode (the body) such that a reaction occurs between the oxygen gas and the aluminum at the surface of the body to produce an aluminum oxide coating. Hydrogen gas is evolved at the cathode.

[0029] The following parameters are monitored to help control the process: current density, voltage, concentration of electrolyte, aluminum concentration, agitation of the electrolyte, and temperature. With regard to current density, the anodizing process 22 is preferably stepped, i.e., the current density is increased over time throughout the anodizing process in discrete amounts. At lower currents, the thickness of an aluminum oxide coating formed on the body forms a diffusion barrier that provides a high sheen finish to the coating. Subsequent anodizing at higher currents then allows for the formation of aluminum oxide coatings that have various impacts on the surface glosses. In one exemplary embodiment of anodizing process 22, direct current is applied at less than or equal to about 5 amps per square foot of body surface (A/ft^2). A subsequent step current density is preferably greater than or equal to about 10 A/ft^2 , with greater than or equal to about 12 A/ft^2 more preferred, and with greater than or equal to about 15 A/ft^2 being even more preferred.

[0030] The current density is preferably kept constant during the anodizing process 22. However, the voltage will vary due to changes in temperature and the increasing oxide thickness, i.e., electrical resistance. Preferably, the voltage is between about 14 to about 18 volts. It is also noted that different alloys will have different voltage requirements to achieve the same current density.

[0031] The sulfuric acid anodizing bath preferably has a concentration of sulfuric acid of about 10 to about 25 weight percent (wt. %), with a concentration of about 12 to about 18 wt. % being more preferred. The temperature of the bath during anodizing, which affects the hardness of the anodized layer, is preferably maintained at about 15°C to about 30°C, with a temperature of about 18°C to about 22°C being more preferred, and with a temperature of about 20°C being even more preferred. Moreover, it is preferred that the bath is continuously agitated to prevent local heating.

[0032] The thickness of the porous oxide layer as well as other properties of the layer (e.g., hardness, pore size, and the like) formed during the anodizing process are functions of various factors such as the time over which the anodizing is effected, the alloy composition of the cathode, the current density, and the electrolyte temperature. Generally, at higher current densities and electrolyzing times, increased thicknesses of the porous oxide layers are deposited. Preferably, the thickness of the porous oxide layer formed during the anodizing process is about 5 micrometers (μm) to about 50 μm, with about 10 μm to about 25 μm being more preferred, and with about 12 μm to about 17 μm being even more preferred. Suitably the anodic oxide grows at a rate of about 0.3 to 0.5 μm per minute and it takes about 30 minutes to build up an anodized layer of 15 μm. Subsequent to the formation of the porous oxide layer in the anodizing process, the anodized body is rinsed.

[0033] The anodized body is then subjected to a coloring process 24. Coloring may be provided to the anodized body by any one or a combination of various methods including, but not limited to, adsorptive coloring, electrolytic coloring, and interference coloring. Interference coloring is a variation of the electrolytic coloring process.

[0034] The adsorptive coloring process (hereinafter referred to as “dying process 26”) is one in which a dye is introduced into the pore openings of the oxide layer. The dyes used in dying process 26 are preferably organic in nature and water insoluble. Such dyes are introduced into the porous oxide layer via dipping, spraying, and the like. Once introduced into the porous oxide layer, the dye is adsorbed in the surface region of the oxide coating via the pores. Because the pore structure of the oxide layer of the anodized body is substantially uniform, and because the particles of a dye are substantially smaller than the particles of paint pigment (and therefore more easily adsorbed into a pore), colors over a wide range of the spectrum may be obtained with a high degree of uniformity. Furthermore, such colors are highly reproducible amongst bodies of the same batch. If dying process 26 is to be utilized in conjunction with any other coloring process, the anodized and dyed body may be rinsed in the rinse cycle prior to being subjected to such other coloring process. If dying process 26 is the only process by which the body is colored, then the body is transferred to a cold seal process 32, as is described below.

[0035] In the electrolytic coloring process, shown at 28, color is imparted to the oxide layer via electrolytic deposition of metal particles at the pores of the oxide layer. The deposition of particles is effected by the application of alternating current to a metal salt solution. Because the sizes of the deposited particles are smaller than the pore openings in the oxide layer, the particles are deposited at the bottoms, as well as the sides, of the pores. Metal salt solutions that may be utilized for the electrolytic deposition of metal particles include, but are not limited to, aqueous solutions of tin,

cobalt, nickel, copper, and the like. If electrolytic coloring process 28 is utilized in conjunction with another coloring process, the electrolytically-colored body may be rinsed in the rinse cycle prior to being subjected to the other coloring process. If electrolytic coloring process 28 is the only process by which the body is colored, then the body is transferred to cold seal process 32, as is described below.

[0036] In the interference coloring process, shown at 30, conventional sulfuric acid anodizing is followed by enlargement of the base of the anodized pores by a further treatment. The original anodized surface is, for example, further anodized in a phosphoric acid electrolyte. This is followed by a conventional electrolytic coloring process such as with a nickel or tin electrolyte. The shallow deposit of the metal particles in the widened pores produces visible interference effects. The effect results from incident light being scattered when passing from two parallel surfaces separated by a difference in the order of a wavelength in the visible range. Different colors are obtained than from conventional electrolytic coloring.

[0037] If an interference coloring process 30 is utilized in conjunction with another coloring process, the interference-colored body may be rinsed in the rinse cycle prior to being subjected to the other coloring process. If interference coloring process 30 is the only process by which the body is colored, then the body is transferred to cold seal process 32, as is described below.

[0038] Where a combination of the above noted coloring processes are employed, it is preferred that the electrolytic coloring process occurs prior to the dying process. Likewise, it is preferred that the interference coloring process occurs prior to the dying process.

[0039] Once the work piece has been dyed, it is sealed, simply exposing the body to cold seal process 32 and/or a hot seal process 34. Cold seal process 32 is preferably based on dipping solutions that contain fluoride or silica compounds in the presence of nickel salts, and often in a water-

alcohol mixture. The water-alcohol solvent apparently lowers the solubility of the salts and facilitates precipitation of the salts within the pores of the anodic film. A preferred cold sealing solution contains a nickel compound such nickel acetate, a fluoride compound, and n-butanol. Preferably, the cold sealing temperature is at about 24°C to about 32°C at a pH of about 5.0 to about 7.0.

[0040] Hot seal process 34 comprises immersing the body in deionized water at a temperature of about 90°C to about 100°C. Hot seal process 34, because of the porosity of the oxide, hydrates the crystalline aluminum layer, which swells the oxide to close the pores, thereby sealing the dye within. The body is then rinsed and subjected to a drying process 36.

EXAMPLES

[0041] No.1. A series of experiments were carried out with 4" x 12" AA6061 panels to establish the anodizing voltage and time for commercial body panels which had been formed by a stamping operation at ambient temperature. After cleaning, etching and desmutting pretreatments as described above the panels were subjected to bright dipping for six minutes in a strong acid solution composed of, by volume 3% nitric acid, 83% phosphoric acid and 14% water. The bath also contained 36g/l aluminum. The aluminum zinc alloy parts were then anodized in 18 volume % sulfuric acid at 13 volts for 35 minutes to produce an 11.5 μm coating. The anodizing was conducted to produce a clear anodized layer for subsequent coloring. The coating had a 155.5 gloss reading at a 60° reading angle.

[0042] The panels were then colored in an aqueous electrolytic bath containing 18 g/l of sulfuric acid and 18 g/l of SnSO₄. Small particles of elemental tin were deposited in the pores of the anodic layer at 8 to 12 volt AC for 30 seconds to 20 minutes. The electrolytically colored panels

displayed very good color uniformity from champagne through several shades of bronze to black depending on the coloring time.

[0043] No.2 A set of AA5083 body panels were colored. These panels had been formed by a superplastic forming process at an elevated temperature. This alloy has a relatively high magnesium content which must be carefully anodized to yield a suitably clear oxide coating for a commercially acceptable coloring result. The parts received a one minute etch in sodium hydroxide, a four minute bright dip treatment in the bath described in the above example, and were slowly anodized at 12 volts in the above described sulfuric acid bath for 40 minutes. The anodized AA5083 panels had a clear oxide coating with a high gloss suitable for an electrodeposited color coating.

[0044] A set of the formed AA5083 panels were variously electrolytically colored in the above described acidic stannous sulfate bath. The panels were each subjected to soak times of 90 seconds and ramp times of 40 seconds to the deposition voltage. The tin was deposited in the pores of the oxide layers for times of 145 seconds, 150 seconds, 160 seconds, 375 seconds, 430 seconds and 1090 seconds to form panel colors ranging from champagne through several shades of bronze to black. The color of each panel was uniform.

[0045] The above-described process provides several advantages over those processes by which aluminum and aluminum alloy bodies and components are presently painted. In particular, the process provides for the coloring of about fifty motor vehicle bodies in one or a combination of colors over about a two and one half hour time period, while conventional paint spray coating processes utilize assembly line formats to systematically coat one body at a time. Because of the well-established tooling of the assembly line format and the automotive industry's reliance on such a format, the potential applicability and benefits of batch- or semi-batch processing is often overlooked.

[0046] Furthermore, automation of the process, i.e., the system-controlled transfer of the bodies between process stations, enables the coloring process to be effected with less manpower. Moreover, the coloring processes described provide attractive alternatives to conventional spray painting of frames and components.

[0047] The actual coloring of the aluminum surfaces provides further advantages to conventionally-colored aluminum bodies and components. More specifically, both the electrolytic deposition of metal particles at the pores of the oxide layer and the deposition of layers to provide interference coloring provide superior coatings that are resistant to fading as a result of exposure to ultraviolet radiation. Moreover, interference coloring generally provides desirable color, gloss, and other surface effects that are not attainable with dye coloring or electrolytic coloring. Again, because the automotive industry has relied on assembly line production and simple spray processes of applying coatings, the potential for other methods of coating have been ignored.

[0048] While the invention has been described with reference to some exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from essential scope of the invention. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.